ВикипедиЯ

R-27 (ballistic missile)

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R-27 (URAV Navy index - **4K10** , START code - **RSM-25** , according to the US and NATO classification - *SS-N-6 Mod 1, Serb*) - Soviet liquid- propellant single-stage ballistic missile of the D-5 complex, deployed on submarines (SLBMs) of project 667A and 667AU. The development of the rocket was carried out at SKB-385 under the leadership of chief designer V.P. Makeev from 1962 to 1968. Entered service on March 13, 1968. Currently withdrawn from service. The last launch as part of combat training was carried out in 1988. From 1991 to 1993, three launches of the Zyb launch vehicle, created on the basis of the R-27, were carried out.

R-27

Navy URAV index - 4K10 START code - RSM-25 US and NATO Defense Code - *SS-N-6 Mod 1, Serb*

Ballistic missile RSM-25. Museum S.P. Koroleva, Peresvet, Moscow region, Russia

Type	SLBM
Status	withdrawn from service
Developer	SKB-385 (GRC named after Makeev)
Chief designer	V. P. Makeev
Years of development	1962 - 1968
Start of testing	September 1965
Adoption	March 13, 1968
Manufacturer	ZMZ / KMZ
Main operators	USSR Navy
Modifications	R-27U, R-27K

Main technical characteristics

Range: 2500—3000 km
Charge power: 1 Mt or 3×200 kt

↓All technical specifications

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Content

Development history

The R-21 missile of the D-4 complex, adopted for service in 1963, with a firing range of 1,400 km, was significantly inferior in basic characteristics to the American Polaris A1 (1960 , 2,200 km) and Polaris A2 (1962, 2,800 km) missiles. To eliminate the backlog, the development of a new rocket was required.

R-21 in the museum

On April 24, 1962, Resolution No. 386-179 of the Council of Ministers of the USSR was issued on the development of a new R-27 missile of the D-5 complex for arming Project 667A submarines . SKB-385 was appointed as the lead developer for the missile and complex , the chief designer was V.P. Makeev. The development of the missile control system was entrusted to NII-592 (chief designer N.A. Semikhatov), and placement of the complex on a Project 667A submarine was assigned to TsKB- 18 (chief designer S. N. Kovalev).

During the development of the rocket, a number of innovative solutions were used, which for a long time determined the appearance of the SKB-385 rockets:

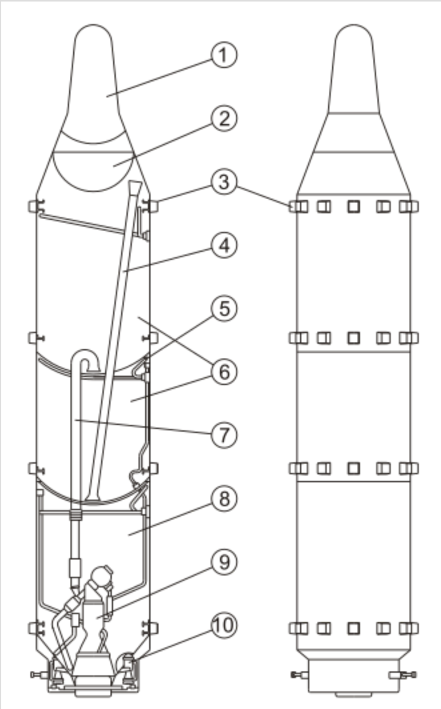
- Maximum use of the entire internal volume of the rocket for placing fuel components in it - the absence of traditional division into compartments, placement of the main engine in the fuel tank (the so-called recessed scheme), the use of a common bottom of the fuel and oxidizer tank , placement of the instrument compartment in the front bottom of the rocket.
- All-welded sealed body made of wafer shells obtained by chemical milling of plates, the material for which was the aluminum-magnesium alloy AMg6.
- reduction in the volume of the air bell due to the sequential start-up at the start of first the steering engines, and then the main engine (“ dynamic bell ”) [1]
- joint development of the rocket and elements of the rocket launch system - abandonment of aerodynamic stabilizers and the use of rubber-metal belt shock absorbers;
- factory refueling of rockets and amplification of fuel components.

These measures made it possible to sharply increase the average density of the rocket layout, thereby reducing its dimensions, as well as reducing the required volume of the shaft and annular gap tanks . Thus, compared to the R-21 missile, the firing range increased by 2 times, the length of the missile decreased by a third, the mass of the launcher decreased by more than 10 times, the mass of the rocket decreased by almost a third, and the volume of the annular gap decreased by almost 5 times. The load on the boat per missile (the mass of missiles, launchers, missile silos and annular gap tanks) has decreased by three times. [2]

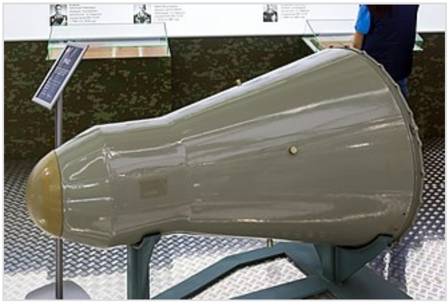
Construction

The R-27 missile was made according to a single-stage design with a monoblock detachable warhead . The rocket body was all-welded, sealed, and made of “wafer” sheets obtained by chemical milling of plates from the aluminum-magnesium alloy AMg6. A 5-6-fold increase in the thickness of the original metal sheet over the thickness of the resulting shell was achieved. Subsequently, when using mechanical milling, this figure was increased to 9. [3] The outer surface of the body was protected by a heat- and moisture-resistant coating based on asbestos textolite . [4]

The rocket was equipped with a 4D10 liquid-propellant rocket engine developed by OKB-2 (chief designer A. M. Isaev) [3] , which consisted of two blocks. The engine consisted of a propulsion block with a thrust of 23 tons [5] and a steering block of two chambers with a total thrust of 3 tons [6] . The liquid rocket engine used self-igniting fuel components. Unsymmetrical dimethylhydrazine (UDMH) was used as a fuel , and nitrogen tetroxide (AT) was used as an



Scheme of the R-27 rocket
1 - monoblock warhead; 2 — instrument compartment; 3 — rubber-metal shock absorbers; 4 — system for overflowing the oxidizer from the lower forecastle to the upper one; 5 — pipes of the tank pressurization system; 6 — upper and lower oxidizer forecastles; 7 — oxidizer intake system; 8 — fuel tank; 9 — propulsion engine block; 10 — steering block


Nuclear monoblock warhead RA82.

oxidizer . [7] The supply of fuel components was carried out by turbopump units . The main engine operated according to a scheme with afterburning of oxidizing gas. The engine thrust was regulated by a fuel flow regulator. The steering unit was made according to a scheme without afterburning, with a gas generator producing gas with an excess of fuel. The steering block's thrust was controlled by a regulator on the common oxidizer line. [8] On the steering block, in the steering drives, jet hydraulic steering machines of a closed circuit were used for the first time, which took fuel from the TPU, used it as a working fluid at an operating pressure of 36-40 atm and then returned it back to the TPU. [9]

For the first time in world practice, the engine was placed in the fuel tank - the so-called “recessed” design. When installing the engine, only permanent connections were used - welding and soldering. The engine became maintenance-free and untestable. The engine was started from one squib , and the entry into the mode was controlled by its own automation. [3] The steering engine's oscillating chambers were installed on the conical bottom of the fuel tank [3] , at an angle of 45° to the rocket stabilization planes [6] . The steel elements of the engine were fastened to the aluminum body using special bimetallic adapters. [10]

To reduce the cavities of the rocket that were not filled with fuel, a common two-layer bottom of the fuel and oxidizer tanks was used. This made it possible to eliminate the intertank compartment . Another innovative solution was factory refueling with subsequent “ampulization” of the tanks by welding the filling and drain valves. [11] Together with work to improve the corrosion resistance of materials, the tightness of seams and joints, this made it possible to set the service life of the missiles in a fueled state to 5 years. And subsequently bring it to 15 [11]

For the first time in the USSR (for SLBMs [6]), elements of the inertial control system were placed on a gyro-stabilized platform . The control system equipment was located in a sealed volume formed by the hemispherical upper bottom of the oxidizer tank. This made it possible to exclude the classic instrument compartment from the rocket design . [4]

The rocket was equipped with a monoblock detachable warhead weighing 650 kg. [12] [13] The power of the nuclear charge placed on it is 1 Mt. [12] [13] To separate the warhead from the rocket, for the first time in the practice of the GRC, an explosive device was used - a detonating elongated cumulative charge based on a high explosive . [14] When firing at the maximum range, a COE of 1.9 km was achieved . [15]

The type of rocket launch is wet , from a pre-flooded shaft. A special adapter was installed at the bottom of the R-27, with which the rocket was docked with the launch pad . In the process of preparing the rocket for launch, the rocket tanks were pressurized . Water entered the mine and the pressure was equalized with the outboard pressure. The cover of the missile silo was opening. To reduce the hydraulic shock that occurs when starting an engine in a silo filled with a rocket, the engine was started in a sealed volume formed by an adapter and a launch pad. A technology for creating a “dynamic bell” was developed. At the beginning of the launch, the steering motors were started in the “gas bell” formed by the adapter. Then, when the rocket began to move, the propulsion engine was started and gradually brought to full thrust mode.

As the rocket moved further, the moment from the oncoming flow of water began to act on it. The reduction of the loads acting on the structure of the rocket emerging from the silo was facilitated by the pre-pressurization of the tanks and the belts of special rubber-metal shock absorbers located on the rocket itself.

Maintenance and procedures for pre-launch preparation and launch of missiles were automated as much as possible. From a single console of the ship's system for daily and pre-launch maintenance of missiles, remote control and monitoring of the status of the systems was provided. The missile weapons control panel was used to carry out complex routine checks and control pre-launch preparations and missile launches. [5]

The initial data for firing was generated by the “Tucha” combat information and control system created under the leadership of chief designer R. R. Belsky. The equipment allowed live firing of two eight-missile salvoes. [5]

The missiles were launched from a depth of 40-50 m, the boat speed was up to 4 knots and the sea state was 5 points . [16] Pre-launch preparation time for missiles is 10 minutes. The firing interval of missiles in one salvo is 8 seconds. [5] The time between salvos is not specified by sources.

Tests

Testing of the D-5 complex was carried out in three stages. The first stage of throwing tests of full-scale prototypes of the R-27 was carried out from the PSD-5 floodable floating test bench in September 1965. Two launches were carried out. [5] [17]

In January 1967, testing of missile prototypes began in the Black Sea from the Project 613D5 submarine (an experimental Project 613D7 submarine converted at Plant No. 444 in Sevastopol [5]) in a submerged position. The delay in work was due to the fact that the boat was received by the customer only on December 23, 1965 . On January 18, 1967, the first launch of a prototype 4K10 rocket was carried out from a depth of 45 m at a boat speed of 3 knots, a sea state of 3 points and a wind speed of 7-8 points. The last, sixth test was carried out on August 10, 1967 . [5]

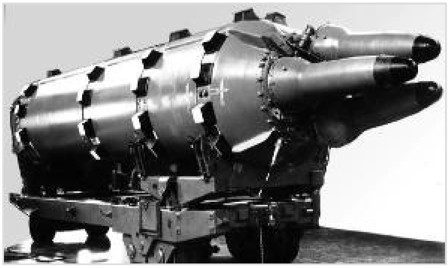
The second stage was carried out in parallel. Flight tests from a ground stand at the Kapustin Yar test site [18] were carried out from June 1966 to April 1967 . A total of 17 launches were carried out, of which 12 were considered successful. [15]

Full-scale joint flight tests of the R-27 began in the Northern Fleet on the lead boat of Project 667A , the K-137 Leninets, in August 1967 . A total of 6 launches were carried out. [15]

The D-5 complex with the R-27 missile was adopted for service on March 13, 1968 by Decree of the USSR Council of Ministers No. 162-164. [5]

Modifications

R-27U



R-27U missile with multiple warhead

The resolution of the Council of Ministers on the modernization of the D-5 complex was issued on June 10, 1971. [19] The goal was to create two versions of the modernized missile. The first option provided for equipping the missile with a warhead with three warheads, while maintaining the maximum firing range. The head part is of the “scattering” type, with blocks without individual guidance. The second option provided for increasing the range and increasing the accuracy of the missile. The modernized version of the complex was designated D-5U, and the missiles - R-27U. A missile was created with three warheads with a capacity of 200 kt each with a maximum range of 2400 km. The multiple warhead was of the so-called “ scattering type ” - the warheads did not have individual guidance. At the end of the active section , the blocks were “pushed” in different directions at low speed. According to the second option, a missile with a range of 3000 km and a monoblock warhead with a power of 1 Mt was created. A CEP of 1.3 km was achieved. [15] The modernization affected the engine (thrust was increased) and the control system. In the west, the missiles were designated SS-N-6 Mod 3 and Mod 2, respectively.

Ship tests of R-27U missiles took place from September 1972 to August 1973. [13] 16 launches were carried out, all considered successful. The R-27U missile was adopted for service on January 4, 1974 by resolution of the Council of Ministers No. 8-5. [19] The D-5U complex with R-27U missiles was equipped with Project 667AU nuclear-powered missile submarines under construction, as well as Project 667A boats after modernization. [15]

R-27K

The initial resolution of the Council of Ministers of April 24, 1962 on the creation of the D-5 complex also provided for the creation of a missile with a homing warhead capable of hitting moving ships. The anti-ship version of the missile was designated R-27K (GRAU index 4K18). In the west, the missile received the designation SS-NX-13. The rocket was equipped with a second stage with a liquid rocket engine developed by KB-2 (chief designer A. M. Isaev). To maintain the dimensions of the missile, the dimensions of the first stage were reduced, which ultimately led to a reduction in the maximum firing range to 900 km. The warhead is monoblock, nuclear, with a capacity of 0.65 Mt. [20]

Guidance in the passive section was carried out using a passive radar seeker , with signal processing by an on-board digital computer system . [21] The initial data for firing was provided by the Legend satellite system or the Success-U aviation system . Data processing on the ship's Kasatka reconnaissance equipment made it possible to determine the coordinates of a group of ships with an accuracy of up to 25 km. This data is constantly becoming outdated - during pre-launch preparation, the target’s location can change up to 150 km. [22] Therefore, control was provided for the second stage by turning on the second stage propulsion system twice during the extra-atmospheric flight phase. Initially, the option of additional correction of the trajectory in the atmospheric section and equipping the rocket with a low-power warhead was also considered. But later this option was abandoned in favor of a purely ballistic one, with a high-power warhead. [23]

Testing of the missile system began in December 1970. [7]

Sh. I. Boksar was appointed technical director and deputy chairman of the State Commission for testing the R-27K missile during launches from a ground-based launch complex .

The ground test cycle at the Kapustin Yar test site included 20 launches (of which 16 were considered successful). [23] The submarine " K-102 " of Project 629 , with 4 missile silos on board, was converted to carry Project 605 missiles. The first launch from a submarine was carried out in December 1972 . And in November 1973, the tests ended with a two-missile salvo. A total of 11 launches were carried out, of which 10 were considered successful. During the last launch, the target ship was hit by a direct hit from a guided unit. [23]

Launch vehicle "Zyb"

In the 1990s, work was carried out to create launch vehicles based on submarine-launched ballistic missiles. The Zyb launch vehicle was created on the basis of the R-27. The rockets were used in research experiments requiring microgravity. The period of weightlessness is from 17 to 24 minutes. The Zyb can launch a payload with a volume of 1.5 m^3 onto a suborbital trajectory. Payload mass is 650 kg at a maximum orbital altitude of 1800 km, or 1000 kg at an orbital altitude of 1000 km. [24]

Three launches were carried out. On December 1, 1991 [24], the Sprint module was launched, developed by the State Research Center together with the NPO Composite . The module was intended for testing technologies for producing superconducting materials and carried 15 exothermic furnaces on board. [25]

On December 9, 1992 and December 1, 1993 [24], the Ether module was launched with the Medusa biotechnological equipment weighing 80 kg. The module, developed jointly with the Center for Space Biotechnology, was intended for research into the technology for purifying biological and medical preparations using electrophoresis under zero-gravity conditions [25] .

Musudan

It is believed that the North Korean Musudan ballistic missile was created on the basis of the Soviet R-27 [26] .

One can also come across statements [27] that the Iranian one, Shahab-3 (Meteor-3), was created on the basis of the Korean rocket, which in turn became the basis for the Safir (Messenger) launch vehicle, until 2017 which provided most of the launches of the Iranian space program . In reality, however, these statements are incorrect: Shahab-3 was developed on the basis of the Nodon-1 OTRK (Korean development of the R-17) [28] , also known as the Nodon-A, and not on the basis "Musudan" (known as "Nodon-B" [26]).

Operation

In total, about 1,800 missiles were produced. The D-5 complex was in operation from 1968 to 1988 . A total of 492 missile launches were carried out, of which 429 were considered successful. The maximum number of launches was in 1971 - 58. This is a kind of record for Soviet and Russian ballistic missiles from submarines. The complex also holds the record for the average annual number of launches - 23.4.

During operation of the D-5U complex, 161 launches were carried out, of which 150 were successful. The last launches of R-27 and R-27U missiles according to combat training plans were carried out in 1988. [15] After this, launches were carried out only for research purposes. During operation, 8 missiles were fired in one salvo twice (once each in the Northern and Pacific fleets). All launches were considered successful. Over the entire period of operation, more than 10 thousand missiles were loaded and unloaded; boats armed with RSM-25 carried out 590 combat patrols in various areas of the World Ocean.

During operation, several accidents occurred with the destruction of missiles. 5 people were killed and one submarine was lost - K-219 .

During loading with a violation of the loading and unloading process, the rocket fell from a height of 10 m onto the pier. The oxidizer tank was destroyed. Two people from the loading party died from exposure to oxidizer vapors on unprotected respiratory organs. [29]

A rocket was destroyed three times in the silo of a boat on combat duty.

During the Ocean-76 exercise , three missiles were pre-launched on the K-444 boat. Two missiles were launched, but the third missile was not fired. Due to a series of human errors, the pressure in the rocket tanks was released before the boat surfaced. The seawater pressure destroyed the rocket tanks, and during the ascent and draining of the mine, the oxidizer leaked into the mine. Thanks to the skillful actions of the personnel, the emergency situation did not develop. [29]

In 1973, on the K-219 boat located at a depth of 100 m, due to a false operation of the irrigation system when the mine drainage valve and the manual valve on the jumper between the main drainage line of the boat and the mine drainage pipeline were open, a communication between the missile silo and sea water occurred. The pressure of 10 atmospheres destroyed the rocket tanks. While draining the mine, rocket fuel ignited, but the timely operation of the automatic irrigation system prevented further development of the accident. The boat returned safely to base. [29]


Fire on K-219 in October 1986

The third incident also occurred on the K-219 boat on October 3, 1986. For unknown reasons, during the dive after a communication session, water began to flow into the missile silo. The crew tried to turn off the automation and drain the water using non-standard means. As a result, the pressure first became equal to the outboard pressure and the rocket tanks collapsed. Then, after draining the mine, fuel components ignited. The automatic irrigation system that was turned off did not work and an explosion occurred. The cover of the missile silo was torn off, and a fire started in the fourth missile compartment. It was not possible to put out the fire on our own. The personnel left the boat, the compartments filled with sea water and the boat sank. During the fire and smoke in the 4th and 5th missile compartments, 3 people were killed, including the commander of the warhead-2 . [29]

The operating experience of RSM-25 missiles was analyzed and taken into account when developing new complexes. As a result, there was not a single loss of life during the operation of subsequent missiles.

Removal from service

The R-27U modification was withdrawn from service even before the collapse of the Soviet Union, in 1989. [20] Other modifications of the missile were removed from service in Russia as part of the implementation of the START-1 treaty . According to the September 1990 memorandum , 192 nuclear warheads were deployed on the R-27 on the territory of the USSR. As of July 1997, Ukraine

, Belarus and Kazakhstan, according to the Lisbon Protocol [30], renounced nuclear weapons, and Russia had 16 deployed warheads on the R-27. [31] A January 2008 memorandum confirmed that all R-27s in Russia had been withdrawn from service. [32]

Tactical and technical characteristics

	R-27	**R-27U**		**R-27K**
Rocket type	SLBM			RCC
GRAU index	4K10 [12]			4Q18 [21]
START code	RSM-25	RSM-25		
NATO code	SS-N-6 Mod 1 "Serb"	SS-N-6 Mod 2 "Serb"	SS-N-6 Mod 3 "Serb"	SS-NX-13
Complex	D-5	D-5U		
Carrier (submarine)	project 667A	project 667AU		project 605
Number of launchers	16	16		4
Rocket data				
Number of steps	1	1	1	2
Engine	Liquid rocket engine 4D10	LRE		
Weight and dimensions				
Rocket mass, kg	14 200	14 200	14,200?	13,250 [21]
Length, mm	8890	8890	8890	~9000 [21]
Diameter, mm	1500			
Payload				
Head mass, kg	650	650	3×170 kg [33]	?
Head type	monoblock		MIRV RT	Homing warhead
Nuclear power	1 Mt (0.6—1.2 Mt [13] [34])	1 Mt (0.6—1.2 Mt [13] [34])	3×0.2 Mt (3×0.1–0.8 Mt [13] [34])	
KVO , km	1.9 (1.1 [13] [34])	1.3—1.8		
Trajectory parameters				
Speed at the end of the active section, m/s	4400 [21]			
Height at the end of the active section, km	120 [21]			
Active section time, s	128.5 [21]			
Maximum altitude, km	620 [21]			
Maximum range, km	2500 [21] (2400 [13] [34])	3000 (3200 [13] [34])	2500 (3200 [13] [34])	900 [21]

Speed of encounter with target, m/s	300 [21]			
Story				
Developer	SKB-385 (GRC named after Makeev)			
Constructor	Makeev V. P.			
Start of development	April 24, 1962	June 10, 1971		
Launches from the stand	September 1965 - August 1967	were not carried out		
Launches from a submarine	December 1972 - November 1973	September 1972 - August 1973		
Adoption	March 13, 1968	January 4, 1974		was not accepted
Manufacturer	Zlatoust Machine-Building Plant Krasnoyarsk Machine-Building Plant			

Project evaluation

The D-4 missile system with the R-27 missile for arming Project 667A submarines was a response to the American Polaris program. [35] In terms of its tactical and technical characteristics, the R-27 missile became an analogue of the Polaris A1 missile, and the monoblock version of the R-27U missile became an analogue of the Polaris A2. The version of the R-27U missile with three warheads was already significantly inferior to its Polaris A3 counterpart in range. At the same time, Soviet missiles were put into service 8-10 years later and had worse accuracy indicators (CAO). [36] In 1970, the United States adopted the Poseidon C3 multiple warhead missile with ten individually targeted units, allowing it to dramatically increase the effectiveness of its naval strategic nuclear forces.

A distinctive feature of Soviet missiles was that they used rocket engines with liquid fuel and were single-stage, while American missiles were created with solid fuel engines and were two-stage. Soviet missiles were slightly lighter, but at the same time had larger dimensions. The fire and explosion hazard was also higher than that of American missiles.

French rocket scientists chose the American path and created their first rockets - M1/M2 and M20 - two-stage with solid propellant engines. In terms of their tactical and technical characteristics, these missiles corresponded to the monoblock versions of the R-27 and R-27U missiles, had comparable accuracy and were put into service several years later than the R-27.

The short range of Soviet missiles necessitated combat patrols of Soviet SSBNs in the areas of operation of powerful anti-submarine defense forces of the US Navy and NATO , which reduced the combat stability of Soviet missile carriers [35] . Despite a number of shortcomings, the USSR managed to create a fairly effective strategic missile system. A number of new technical solutions were tested on the R-27 rocket. The use of these developments on missile systems with R-29 and R-29R missiles subsequently made it possible to bridge the gap with the United States.

TTX	Polaris A1	Polaris A2	Polaris A3	R-27	R-27U		Poseidon C3	R-29	M1	M20
A country										
Year of adoption	1960	1962	1964	1968	1974		1970	1974	1972	1976
Maximum range, km	2200	2800	4600	2500	3000	2500	4600	7800	3000	3200
Throwing weight, kg	500	500	760	650	650	>650	2000	1100	1360	1000
Head type	monoblock		MIRV RT	monoblock		MIRV RT	MIRV IN	monoblock		
Power, kt	600	800	3×200	1000	1000	3×200	10×50	1000	500	1200
KVO , m	1800		1000	1900	1300—1800		800	1500		1000
Launch weight, t	12.7	13.6	16.2	14.2			29.5	33.3	20	
Length, m	8.53	9.45	9.86	9.65			10.36	13	10.67	
Diameter, m	1.37			1.5			1.88	1.8	1.49	
Number of steps	2			1			2	2	2	
engine's type	Solid propellant rocket engine			LRE			Solid propellant rocket engine	LRE	Solid propellant rocket engine	
Start type	dry			wet			dry	wet	dry	

Notes

1. SKB-385. Decree. op. — P. 88.
2. SKB-385. Decree. op. — P. 88-89.
3. SKB-385. Decree. op. — P. 87.
4. Shirokorad, 2003, p. 515.
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6. Strategic nuclear weapons of Russia. Decree. op. — P. 276.
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12. Strategic nuclear weapons of Russia. Decree. op. — P. 277.

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15. Strategic nuclear weapons of Russia. Decree. op. — P. 278.
16. Shirokorad, 2003 , p. 516-518.
17. Discrepancy. According to the reference book "Strategic Nuclear Weapons of Russia," page 278, 6 launches were carried out from a floating stand.
18. *Alexander Tikhonov.* Test site near the Volga (http://www.redstar.ru/2009/01/14_01/2_02.html) . Red Star (January 14, 2009). Access date: December 6, 2009.
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